Geophysical Research Abstracts
Vol. 21, EGU2019-8536, 2019
EGU General Assembly 2019
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Flood forecasting in small catchments: A comparative application of long short-term memory networks and artificial neural networks

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The application of data-driven methods for predicting hydro-meteorological variables has been increasing rapidly, especially in the field of flood forecasting. Common approaches are feed-forward multi-layer perceptrons (MLPs), even if they learn the relation between input and output without considering the sequential order in data. Therefore MLPs require lagged input vectors, although the optimal shift depends on hydrological conditions. Recurrent neural networks (RNNs) avoid this problem by their architecture respectively their state vector, which represents a short-term memory. However, it only contains information from the last few time steps.

This study uses the more complex long short-term memory (LSTM) networks. As a special RNN, they can learn long-term dependencies with a gated cell state. In order to find its benefits for flood forecasting, predictions of LSTM and MLP are compared for three data sets, characterized by an increasing degree of determination: (i) real world data from small, fast responding Saxon catchments (Germany) with hourly resolution, (ii) conceptual data, where flow data is produced by a simple storage concept, and (iii) synthetic data obtained from a sine function. The evaluation focuses on typical limitations of data-driven methods, e.g. phase shift error, oscillations and total loss of information. First results prove, that the LSTM predicts all data sets with less oscillations. Furthermore, the potential of LSTMs for reducing phase shift errors increases from real world to conceptual and synthetic data.